

capacity of the foil bearing and the high static stiffness and control versatility of the active magnetic bearing. Hence, the hybrid foil magnetic bearing system implements a significant advance in range of operation and reliability.

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*Inquiries concerning rights for the commercial use of this invention should be addressed*

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## Using Plates To Represent Fillets in Finite-Element Modeling

Structural deflections are approximated by use of simplified computational submodels of fillets.

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A method that involves the use of fictitious plate elements denoted bridge plates has been developed for representing the stiffnesses of fillets in finite-element calculations of deflections, stresses, and strains in structures. In the absence of this method, it would be necessary to either neglect the effects of fillets to minimize the computational burden or else incur a large computational burden by using complex computational models to represent the fillets accurately. In effect, the bridge plates of the present method are reduced-order models of fillets that do not yield accurate stresses within fillets but do make it possible to accurately calculate the dynamic characteristics of the structure and to approximate the effects of fillets on stresses and strains elsewhere in a structure that contains the fillets. Such approximations are accurate enough for final modal analysis and preliminary stress analyses.

In a finite-element model according to this method, the model of a fillet includes bridge plates that connect the tangent lines of the fillets. For a given fillet, the bridge plates are characterized by a thickness ( $t_b$ ) and a pseudo Young's modulus ( $E_b$ ) to represent the mass and stiffness of the fillet as accurately as possible. It is necessary to calculate  $t_b$  and  $E_b$  in advance, by means of the procedure described in the next paragraph.

One generates two simultaneous nonlinear wide-beam-deflection equations for the rotation at the tangent lines: an equation applicable to the bridge-plate representation and an equation derived from an analytic representation of the fillet. These equations are formulated in terms of the independent variables  $r/t$  and  $t_{\text{wall}}/t$ , where  $r$  is the fillet radius,  $t_{\text{wall}}$  is the thickness of the non-filletted section of a wall adjacent to the filleted section,

and  $t$  is a thickness variable, the value of which one seeks. The equations are solved numerically to obtain  $t_b$  and  $E_b$ . In addition, surface fits of the solutions are obtained for use as the equivalent of closed-form equations for  $t_b$  and  $E_b$ .

The method has been verified in calculations pertaining to a representative filleted structure. The bridge-plate model yielded a level of accuracy for the calculation of natural frequencies and mode shapes better than or equal to that obtained by use of a high-fidelity solid model of the fillet, even though the bridge-plate model contained 90 percent fewer degrees of freedom.

*This work was done by Andrew Brown of Marshall Space Flight Center. For further information, access the Technical Support Package (TSP) free on-line at [www.techbriefs.com/tsp](http://www.techbriefs.com/tsp) under the Mechanics category.*  
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